CLAIMS

What is claimed is:

1. A method of determining a parameter of interest for a region of an earth formation using a nuclear magnetic resonance (NMR) instrument conveyed in a borehole, the method comprising:
   (a) producing a static magnetic field in a region including said region of interest;
   (b) transmitting a sequence of radio frequency (RF) pulses for producing an RF magnetic field in said region, said RF magnetic field having a spatially varying intensity in said region and a direction substantially orthogonal to a direction of said static magnetic field, a subset of said RF pulses further having a pulse length related to zeros of a Bessel function;
   (c) receiving NMR signals having amplitudes produced by said RF magnetic field; and
   (d) determining said parameter of interest using said amplitudes.

2. The method of claim 1 wherein said parameter of interest comprises a spin density function.

3. The method of claim 1 wherein said NMR signals comprise free induction decay signals associated with said subset of RF pulses.

4. The method of claim 1 wherein said subset of RF pulses comprises tipping pulses, the pulse sequence further comprising a plurality of refocusing pulses associated with said tipping pulses, and wherein said NMR signals comprise spin echo signals.

5. The method of claim 3 wherein determining said parameter of interest further comprises performing an inverse Hankel transform on said signals.

6. The method of claim 5 wherein determining said parameter of interest further comprises using a spatial mapping to map said spin density to a spatial location.

7. The method of claim 4 wherein said sequences of RF pulses are of the form:

$$[\tau_j - \frac{TE}{2} - (R - TE)_i - TW]_j$$

where TE is a time interval between refocusing pulses R, τ_j is a tipping pulse, TW is a wait time, i is the index of the number of refocusing pulses, and j is the index of the number of CPMG (or modified CPMG) sequence acquired for a single tipping pulse.

8. The method of claim 7 wherein determining said parameter of interest further comprises summing the spin echo signals resulting from said sequence of RF pulses over the index j for a selected value of i.

9. The method of claim 8 wherein said summing is a weighted summing.

10. The method of claim 9 wherein determining said parameter of interest further comprises using a spatial mapping to map said spin density to a spatial location.

11. The method of claim 6 further comprising determining spins associated with a portion of the region of interest outside said borehole.

12. The method of claim 10 further comprising determining spins associated with a portion of the region outside said borehole.

13. The method of claim 6 further comprising partitioning said spins into azimuthal sectors.

14. The method of claim 10 further comprising partitioning said spins into azimuthal sectors.

15. The method of claim 1 further comprising repeating (a) – (d) for a number of different azimuthal orientations of said instrument.

16. The method of claim 15 further conveying said instrument into said borehole on a bottom hole assembly.

17. An apparatus for determining a parameter of interest for a region of an earth formation comprising:

(a) a magnet for producing a static magnetic field having a direction within the region;

(b) a transmitter for transmitting a sequence of radio frequency (RF) pulses for generating a RF magnetic field in said region, said RF magnetic field having a spatially-varying intensity in said region and a direction substantially orthogonal to the direction of the static magnetic field,

(c) a processor for controlling said transmitter and defining a subset of said RF pulses to have pulse lengths related to zeros of a Bessel function;

(d) a receiver for receiving NMR signals produced by said RF magnetic field; and

(e) a processor for determining said parameter of interest from amplitudes of said NMR signals.

18. The apparatus of claim 17 wherein said parameter of interest comprises a spin density function.

19. The apparatus of claim 17 wherein said NMR signals comprise free induction decay signals associated with said subset of RF pulses.

20. The apparatus of claim 17 wherein pulses of said subset of RF pulses are tipping pulses, the pulse sequence further comprising a plurality of refocusing pulses associated said tipping pulses and wherein said NMR signals comprise spin echo signals.

21. The apparatus of claim 17 wherein said processor in (e) is configured so as to determine a spin density as a function of said RF field intensity.

22. The apparatus of claim 21 wherein said processor is configured to transform said spin density to a spatial location.

23. The apparatus of claim 21 wherein said sequences of RF pulses are of the form: $[\tau_j - \frac{TE}{2} - (R - TE)_i - TW]_j$

where TE is a time interval between refocusing pulses R, τ_j is a tipping pulse, TW is a wait time, i is the index of the number of refocusing pulses and j is

the index of the number of CPMG (or modified CPMG) sequence acquired for a single tipping pulse.

24. The apparatus of claim 17 wherein the same antenna is used for transmitting said RF pulses and receiving said signals.

25. The apparatus of claim 17 wherein said processor in (c) and said processor in (e) are the same.